ORD Participation in Development of UNEP Report
on *Environmental Effects of Ozone Depletion*

The Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer are provided advice by three Assessment Panels: Science, Environmental Effects, and Technology and Economics. The environmental panel provides periodic assessments at least every four years that are coordinated through the United Nations Environment Programme (UNEP). The report entitled *Environmental Effects of Ozone Depletion: 1998 Assessment* has just been published as a Special UNEP publication and also as a special volume of the *Journal of Photochemistry and Photobiology B: Biology*. Dr. Richard Zepp (ORD/NERL) is one of the Lead Authors.

The 1998 assessment focuses on new information produced since 1994. It also includes earlier results as background information, so that it can be read without having previous reports at hand.

In 1994, the ozone layer was predicted to become thinner until about 1998, and to recover gradually thereafter. Taking into account new information, it is now expected that the most vulnerable period for ozone depletion will be extended into the coming two decades. Scientific studies are continuing on the most important effects, and on what can be done to prevent or mitigate them. The problem is now complicated by new evidence that interactions of UV radiation with the environment are interconnected with other environmental factors including those associated with global change. A few highlights of this report follow.

The report reviews satellite-based observations of atmospheric ozone and clouds that are being used, together with models of atmospheric transmission, to provide global coverage and long-term estimates of surface UV-B radiation. However, the limitations of satellite-derived UV estimates should be recognized. For example, ground-based measurements show that summertime erythemal UV irradiances in the Southern Hemisphere exceed those at comparable latitudes of the Northern Hemisphere by up to 40%, whereas corresponding satellite-based estimates yield only 10 to 15% differences. Atmospheric pollution may be a factor in this discrepancy between ground-based measurements and satellite-derived estimates. The report concludes that UV-B measurements at more sites are required to determine whether the larger observed differences are globally representative.

Risk assessments for the US and the Northwestern Europe indicate that the increase in the risk of cataract and skin cancer due to ozone depletion would not have been adequately controlled by implementation of the Montreal Protocol (1987) alone but can be achieved through implementation of its later provisions that were approved in Copenhagen (1992) and Montreal (1997). The increases in UV-B radiation associated with ozone depletion are likely to lead to increases in the incidence and/or severity of a variety of short-term and long-term health effects, including adverse effects on the eye, both adverse and beneficial effects on the immune system, and effects on the skin such as photoaging and skin cancer.

Increased UV-B can be damaging for terrestrial organisms including plants and microbes, but these organisms also have protective and repair processes. The balance between damage and

protection varies among species and even varieties of crop species. Many species and varieties can accommodate increased UV-B. Terrestrial ecosystem responses to increased UV-B are evident primarily in interactions among species, rather than in the performance of individual species. Much of the recent experimentation indicates that increased UV-B affects the balance of competition among higher plants, the degree to which higher plants are consumed by insects, and susceptibility of plants to pathogens. Responses of plants and other organisms to increased UV-B are modified by other environmental factors such as CO_2, water stress, mineral nutrient availability, heavy metals and temperature. Many of these factors also are changing as the global climate is altered.

Recent studies continue to demonstrate that solar UV-B and UV-A affect the growth, photosynthesis, protein and pigment content, and reproduction of a variety of aquatic organisms, such as phytoplankton, macroalgae and seagrasses, zooplankton and other organisms such as sea urchins, corals and amphibians. Polar marine ecosystems, where ozone-related UV-B increases are the greatest, are expected to be the oceanic ecosystems most influenced by ozone depletion. Considerable uncertainties remain in estimating long-term consequences in both Arctic and Antarctic productivity, including possible shifts in community structure.

Effects of increased UV-B on emissions of trace gases and on mineral nutrient cycling in the terrestrial biosphere have been confirmed by recent studies of a range of species and ecosystems. Enhanced UV radiation causes changes in the chemical composition in living plant tissue, photodegradation (breakdown by light) of dead plant matter, including litter, and other alterations that can affect carbon capture and storage in biomass within natural terrestrial ecosystems. Observations in natural aquatic ecosystems have indicated that organic matter is the primary regulator of UV-B penetration. Enhanced UV-B can affect the balance between the biological processes that produce the organic matter and the chemical and microbial processes that degrade it. Photoinhibition of surface aquatic microorganisms by UV-B can be partially offset by photodegradation of dissolved organic matter to produce substrates, such as organic acids and ammonium, that stimulate microbial activity. These changes, which are reinforced by changes in climate and acidification, result from clarification of the water and changes in light quality.

The report also provides updated information on the effects of enhanced UV radiation on air quality and the oxidizing capacity of the lower atmosphere. It discusses recent research on trifluoroacetate, a persistent breakdown product of some of the CFC substitutes. Also, recent studies of the effects of UV radiation on materials such as synthetic polymers and biopolymers are covered in the last part of the report.

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